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THE DISTRIBUTION, ECOLOGY AND PHYTOSOCIOLOGY OF RARE *POTAMOGETON* SPECIES IN CENTRAL PART OF WESTERN UKRAINE

Introduction

The genus *Potamogeton* L. is one of the most important among aquatic plants. It occurs in all parts of the world except warm and cold desert. But up to now our knowledges on its distribution, syntaxonomy, ecological preferences and life biology is still scarce [Wiegleb, 1988; Zalewska-Gałosz, 2008]. *Potamogeton* species are belong to weakly investigated representatives of our flora. The strict definition of some species, particularly angustifoliate, is difficult, especially during the vegetative stages. Often they are determined incorrectly, so far many distribution data are false.

Some *Potamogeton* species have a cosmopolitan distribution. They display high levels of polymorphism and phenotypic plasticity in response to variations of environmental factors; these qualities allow them to occur over a wide range of conditions. Other species, however, have narrower tolerance. Their distribution and abundance are influenced by variations of environmental factors [Preston, 1995]. The pollution and eutrophication of water habitats can cause their disappearing in many aquatic ecosystems.

Western part of Ukraine is characterized by a scarcity of natural water reservoirs. However, the lack of natural water bodies is compensated by many artificial reservoirs that were built by man for agricultural, flood-control or recreational purposes. They have become an important habitat for many rare and threatened plants, in particular *Potamogeton* species. The investigations variability of physical-chemical characteristics of the man-made water ecosystems and their biocoenotic features are important as they provide special habitats for rare aquatic plants [Nowak et al., 2007]. Almost all rare species, except one locality of *P. alpinus* Balb., were found in artificial reservoirs.

The habitat requirements of *Potamogeton* species have been studied in some countries, particular attention being given to various aspects of the relationships

between different species and environment. Many authors have investigated the relationships between the occurrence of some species in relation of chemical composition of substrate [Wiegleb, 1988]. In Ukraine ecological studies most often were represented as indication of habitat requirement by macrophytes. Some authors have investigated also ecological structure of aquatic plants and their bioindicator values. First attempt at determination of indicator features of these plants in Ukraine was given in monograph "Macrophyty…" [Макрофиты…, 1993]. In this work authors have investigated ecological and biological structure of aquatic species and have given of characteristic of hydrophilic ecobiomorph of Ukraine. Ecological investigation of aquatic species on the studied area (Lviv localities) have studied by R. Danylyk. Investigation of ecobiomorphs some aquatic species on the Opillja territory was carried out by O. Nakonachnyj; Ternopil plateau – by V. Sobko and R. Javorivskyj. They have installed high level of differentiation of biomorphologic structure of hydrophytes [Борсукевич, 2007]. So far, studies of habitat requirements of *Potamogeton* species and especially rare and threatened one, have been not numerous. Nobody studied the influence of nature and chemical composition of substrate on the occurrence ones. Therefore attempt at determination of habitats character of these species is topical.

The aims of present study are: to determine the range of habitat conditions of the rare species; to provide information on ecological conditions of the rare *Potamogeton* species and to present the information on distribution and on location of these species in some western regions of Ukraine.

Matherial and methods

The studies are based on the herbarium data and the own field investigations. The studied area include of the territory of Lviv, Ternopil and Ivano-Frankivsk regions. On this territory are presented all types of aquatic ecosystems, all types of substrate and most in Ukraine ranging of elevation, 200 to 2061 m. We have studied specimens of collections in KW, LW, LWS, LWKS, KRAM, KRA, CHER. Field surveys of *Potamogeton* taxa were carried out in western part of Ukraine during the seasons of 2005-2010. They included collecting of plant materials, carrying out phytosociological releves, habitats classification and population structure. The phytosociological releves were sampled using phytosociological Braun-Blanquet approach [Matuszkiewicz, 1981; Tomaszewicz, 1980]. The phytosociological releves were made in all type of reservoirs.

The object of the investigation was rare and threatened species. Threat level was determined according to the list of rare macrophytes of Ukraine [Макрофиты…, 1993]. Totally, 8 species have been classified as rare and threatened such as: *P. acutifolius* Link, *P. alpinus, P. compressus* L., *P. friesii* Rupr., *P. gramineus* L., *P. praelongus* Wulf., *P. obtusifolius* Mert. et Koch, *P. trichoides* Cham. et Schlecht. The availability of *P. obtusifolius* is not confirmed and there

are only old herbarium specimens from studied territory. We investigated also communities including these species. Communities of *P. trichoides* were not included to the phytocoenotic table (Tabl. 1), because of their spreading and expansion rate with no visible threat symptoms in any type of habitats.

Table 1. Rare species of the genus *Potamogeton* in pondweed communities

Number of releve	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Depth, cm	60	80	120	100	150	50	50	30	100	90	100	120	30	80	140	100
Number of species	7	8	10	10	5	16	4	6	9	10	9	5	6	3	3	5
Total cover (%)	90	80	50	70	70	90	80	90	90	90	90	9	100	80	50	70
Releve area, m2	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
D.s.ass. Potametum acutifolii																
Potamogeton acutifolius	.	.	.	.	.	+	4	+	r	r	.	.	.	.	.	.
D.s.ass. Potametum compressi																
Potamogeton compressus	1	5	3	2	.	.	.	.	.	.	.	.	.	.	.	.
D.s.ass. Potametum friesii																
Potamogeton friesii	.	2	+	.	.	.	.	.	.	.	+	.	.	.	.	.
D.s.ass. Potametum graminei																
Potamogeton gramineus	.	.	.	.	4	4	.	.	.	.	.	+	.	.	.	.
D.s.ass. Potametum praelongi																
Potamogeton praelongus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	4
D.s.ass. Potametum alpini																
Potamogeton alpinus	.	.	.	.	.	.	.	.	.	.	.	.	r	5	.	.
D.s. O. Cl. Potametalia, Potametea																
Potamogeton natans	.	.	.	.	.	+	.	5	.	r	.	5	5	.	.	.
Potamogeton pectinatus	.	.	.	.	1	.	.	.	.	.	+	.	.	.	.	.
Potamogeton pusillus	.	+	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Myriophyllum spicatum	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	+
Myriophyllum verticillatum	+	+	r	.	.	.	.	.	r	.	r	2	.	.	.	.
Ceratophyllum demersum	.	.	.	.	+	.	.	.	2	4	+	.	.	.	.	.
Batrachium circinatum	.	.	r	r	.	+	.	.	.	.	5	.	.	.	.	.
Batrachium trichophyllum	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.
Elodea canadensis	+	.	+	+	.	.	.	.	+	.	+	+	2	.	.	+
Nuphar lutea	.	1	.	4	.	.	.	.	5	.	.	.	.	.	.	.
D.s.cl. Lemnetea																
Lemna minor	.	.		+	+	.	2	+	+	+	.	.	.	.	.	1
Lemna trisulca	.	.	+	+	.	.	1	2	2	+	.	.	.	.	.	.
Spirodela polyrhiza	.	.		+	.	.	.	.	+	.	.	.	.	.	.	.

Table 1. cont.

Number of releve	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Accompanying																
Alisma plantago-aquatica	.	.	r	.	.	r	.	.	.	.	+	.	.	.	.	.
Chara sp.	.	.	.	.	.	.	.	.	.	+	.	2	.	.	.	.
Eleocharis acicularis	5	2	1	1	.	+	.	.	.	.	2	.	.	.	.	.
Eleocharis palustris	.	.	.	.	.	r	.	.	.	.	.	.	+	.	.	.
Glyceria maxima	.	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.
Sagittaria sagittifolia	.	.	+	+	.	r	.	+	.	.	.	.	.	.	.	.
Sparganium erectum	.	.	.	.	.	1	.	.	.	r	.	.	.	.	.	.
Typha latifolia	.	.	.	.	.	2	.	r	.	.	.	.	+	.	.	.
Utricularia vulgaris	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	+

Other species: *Callitriche cophocarpa* (1: +); *Chara delicatula* (5: 3); *Drepanocladus aduncus* (7: +); *Glyceria fluitans* (5: +); *Hottonia palustris* (1: r); *Hydrocharis morsus-ranae* (9: 1); *Juncus articulatus* (5: +); *Nymphaea alba* (10: 5); *Oenanthe aquatica* (2: r); *Phragmites australis* (5: 1); *Potamogeton lucens* (10: +); *Potamogeton perfoliatus* (15: +); *Rorippa amphibia* (1: +); *Equisetum fluviatile* (14: +); *Carex rostrata* (14: +).
Locations: 1-4 – Lviv region, Jastrubychi, drainage ditch, influent channel (2005/08/16; 2008/06/30); 5 – Ivano-Frankivsk region, Bilshivci, fish culture pond (2010/06/10); 6 – Lviv region, Jastrubychi, peat-pit; 7 – Lviv region, Stanislavchyk, depression on the meadow (2007/08/05); 8 – Ivano-Frankivsk region, Ozerjany, interfiled water eyes (2007/08/11); 9 – Ternopil region, Reniv, oxbow-lake (2008/08/19); 10 – Ternopil region, Borshchiv, recreation pond (2006/08/15); 11 – Lviv region, Janiv, fish culture pond (2005/08/25); 12 – Lviv region, Korchyn, peat-pit (2007/07/02); 13 – Ivano-Frankivsk region, Nyznij Strutyn, dam reservoir (2007/08/23); 14 – Zakarpattja region, Ridge Svidovets, lake Dogjaska (2010/07/21); 15-16 – Lviv region, Grushiv, sand-pit (2005/08/26).

Results

The 16 species (*P. acutifolius*, *P. alpinus*, *P. berchtoldii* Fieb., *P. compressus*, *P. crispus* L., *P. friesii*, *P. gramineus*, *P. lucens* L., *P. natans* L., *P. nodosus* Poir., *P. obtusifolius*, *P. pectinatus* L., *P. perfoliatus* L., *P. praelongus*, *P. pusillus* L., *P. trichoides* Cham. et Schlecht.) have been recorded on the studied territory according to our own investigation [Борсукевич, 2010] and taking into consideration literary distribution data of *Potamogeton* species [Дубина, Чорна, 1987]. They are representing 80% from all Ukrainian *Potamogeton* species.

The investigations of *Potamogeton* species (in the frame of floristic studies) began at the middle of 19 century. For the last 150 years they were irregular. Most precise floristic field works were carried out by Polish botanists at the beginning of XX century [Борсукевич, 2007]. Therefore we have complete literature and herbaria floristic data from this period. Thus we can determine the features of

distribution of *Potamogeton* species in the past and nowadays (Fig. 1). The figure shows that the rare *Potamogeton* species were more curren in the past. This fact can be explained by the lower degree of eutrophication and pollution and a little human pressure.

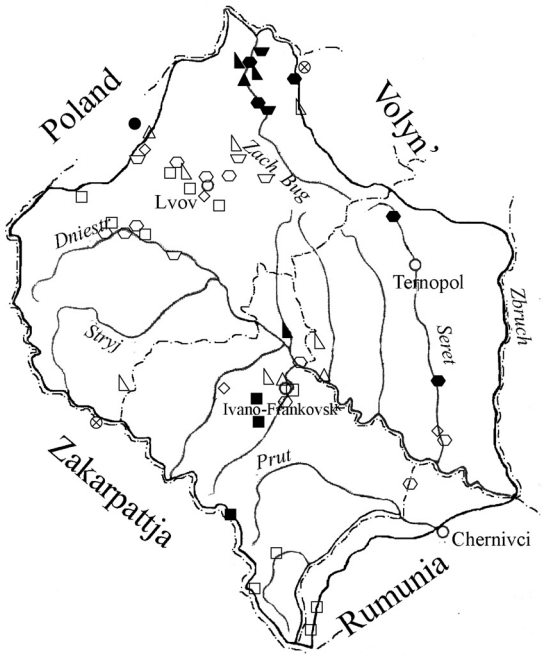

Fig. 1. Distribution of rare and threatened species of the genus Potamogeton in studied area: P. obtusifolius (◇ – herbaria specimens); P. praelongus (⊗– herbaria specimens, ● – personal data); P. compressus (△ – herbaria specimens, ▲ – personal data); P. alpinus (□ – herbaria specimens, ■ – personal data); P. acutifolius (⬡– herbaria specimens, ⬢ – personal data); P. gramineus (◺ – herbaria specimens, ◣ – personal data); P. friesii (▬ – herbaria specimens, ▭ – personal data)

Potamogeton species richness as well as species richness in general, are changing also with increasing elevation. This change of distribution can be attributed to climatic deterioration. A study of many aquatic reservoirs of studied area ranging from 200 to 2000 m found that water temperature (which is strongly and linearly correlated with altitude) was the strongest predictor of macrophyte richness, followed by ecological factors: transparency, pH, alkalinity, and conductivity. Aquatic ecosystems at high altitude are extreme environments in which physical stressors associated with ice and snow (winter cover, valanche) and severe climate are limiting factors for the distribution of aquatic plants [Lacoul and Freedman, 2006]. Thus, in high-mountain level of Carpathians grows only two

Potamogeton species – *P. alpinus* and *P. natans*. A few species grows also in the forest's zone of Carpathians – *P. berchtoldii, P. perfoliatus*, *P. praelongus*. Another species not occur over 400 m.

The *Potamogeton* species have irregular distribution in studied area. The half of the species is known just from several localities: 3 occur very seldom (1-5 localities), 6 – infrequently (6-20 localities), 7 – sporadically.). All rare and threatened species are known only from several places (Fig. 2). One of the reasons of it can be their ecological requirements. Most of them have more stenotopic character than at wide-spread species.

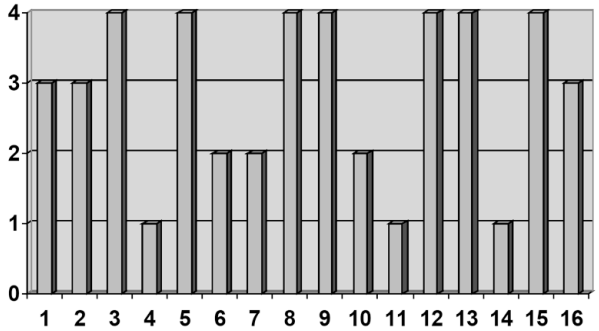

Fig. 2. Distribution of *Potamogeton* species in studied area:
1 – *P. acutifolius*; 2 – *P. alpinus*; 3 – *P. berchtoldii*; 4 – *P. compressus*; 5 – *P. crispus*;
6 – *P. friesii*; 7 – *P. gramineus*; 8 – *P. lucens*; 9 – *P. natans*; 10 – *P. nodosus*; 11 – *P. obtusifolius*;
12 – *P. pectinatus*; 13 – *P. perfoliatus*; 14 – *P. praelongus*; 15 – *P. pusillus*;
16 – *P. trichoides*. Frequency of occurrence: 1 – 1-5 localities; 2 – 6-10 localities;
3 – 10-20 localities; 4 – >20 localities

In the group of rare species were observed 8 species, 7 of which are included to the Red list of water macrophytes of Ukraine (1 as criticaly endengared, 6 as endangered; 1 – regionally rare). Unfortunately none of them is protected in reserves also they aren't enlisted in the Red book of Ukraine.

Comparison of the habitats of 8 rare *Potamogeton* taxa indicates that differentiation of the species is confirmed by differentiation of certain properties of water or substrate. We investigated pH (soil acidity), total salt regime, carbonate content in soil, nitrogen content in soil. They are one of the most important compounds, on which plants react sensitively. The scales elaborated by Diduch was used as a base [Didukh, 2011]. They based on Tsyganov, Ramensky, Ellenberg, Landolt, Zarzycki et other ecological scales' comparisons (Fig. 3) [Ellenberg, 1974; Zarzycki et al., 2002]. We investigated also phytocoenoses structure of communities with rare *Potamogeton* species.

The populations of *P. praelongus* has been considered as most endangered within large areas of its distribution range in Europe, as well as in Ukraine. *P. praelongus* is depend on very clear waters and its distribution is limited in many European countries by water pollution. *P. praelongus* is very rare in Ukraine. It can't exist in extremely disturbed as well as in temporarily polluted habitats. It prefers cold, clear, alkaline, and meso- or eutrophic waters of 100-200 cm depth, both standing and flowing. In studied area this species creates the species-poor communities occurring only in one sand-pit that is dominated by *P. praelongus* and *Myriophyllum spicatum* (Tabl. 1). According to ecological requirements *P. praelongus* is neutrophil, eutroph, hemi-carbonatophil, hemi-nitrophil.

The populations of *P. alpinus* develop in standing or slowly running waters, with low calcium content. It grows in mesotrophic or eutrophic waters revealing from slightly acidic to moderately alkaline reaction, and on various substrata, like peat, sand, loam or clay. *P. alpinus* is typical for cold, clear waters of 30-50 cm depth. It disappears in extremely disturbed, eutrophicated and also polluted habitats. *P. alpinus* is rare in Ukraine but occurs in high-mountain part of Carpathians where it creates very species-poor communities, dominated by *P. alpinus* only, with a high cover rate. The association has the lowest species richness among the all investigated communities in our study. In another parts of the studied area it not creates any communities and sometimes grows as accompanying species in Potametum natantis communities (Tab. 1). According to ecological requirements *P. alpinus* is sub-acidophil, semi-eutroph, carbonatophil, sub-anitrophil.

The populations of *P. acutifolius* occur in standing, shallow, small and eutrophic waters with large mud deposits. It grows in mesotrophic waters of 30-50 cm depth, with a considerably high alkaline reaction on peat, loam or clay substrate. Communities, dominated by *P. acutifolius* are very rare and endangered in Europe. In Ukraine *P. acutifolius* is known as vulnerable. In western part of Ukraine it usually not creates any communities and sometimes grows as accompanying species in different communities of class Potametea (Tab. 1). According to ecological requirements *P. acutifolius* is neutrophil, mesotroph, acarbonatophil, hemi-nitrophil.

The populations of *P. compressus* occur in slightly flowing shallow waters with large mud or peat deposits. It is typical for clear, meso- or eutrophic waters of 50-100 cm depth. *P. compressus* is rare in Ukraine. It not creates any communities in western part of Ukraine and sometimes grows as accompanying species in different communities of class Potametea (Tab. 1). According to ecological requirements *P. compressus* is neutrophil, semi-eutroph, hemi-carbonatophil, nitrophil.

The populations of *P. gramineus* occur in fish-ponds, peat-pits, drainage ditches and channels. It grows in mesotrophic or oligotrophic shallow waters of 50-150 cm depth

revealing from slightly acidic or neutral reaction, and on various substrata, like peat, loam or clay. *P. gramineus* is quite rare in Ukraine. It disappears in old reservoirs with high trophy level. On studied area it creates the rich and varied pondweed assemblage, where many other submerged species occur, e.g. *P. compressus, P. natans, P. pusillus*. In shallow waters assemblage include also riparian plant species: *Typha latifolia, Sparganium erectum* etc. (Tabl. 1). According to ecological requirements P. gramineus is neutrophil, semi-eutroph, hemi-carbonatophil, sub-anitrophil.

The population of *P. friesii* occurs in standing, shallow waters of 50-100 cm depth, mainly in drainage ditches, channels and ponds, rarely in brackish water. *P. friesii* is very rare in Ukraine. It disappears in eutrophicated or polluted habitats.

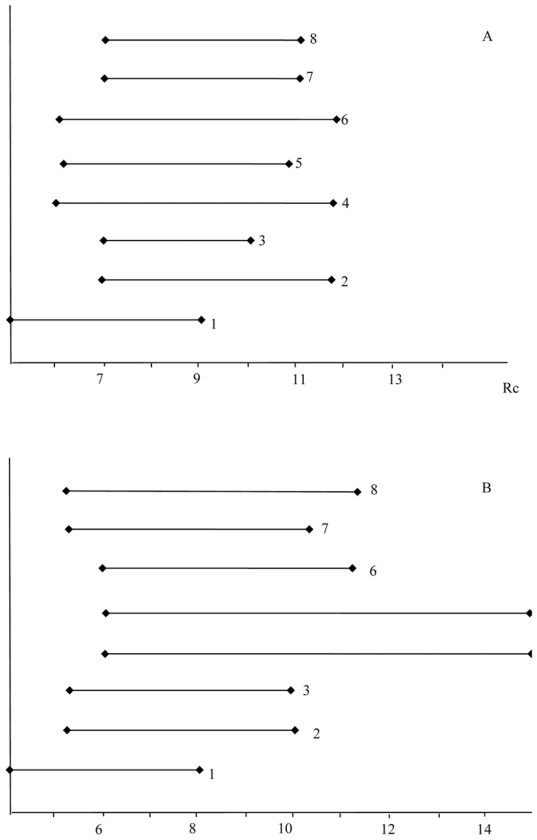

Fig. 3. Distribution of amplitudes of investigated rare *Potamogeton* species concerning ecological factors:
A – by the relation of species to soil acidity (Rc);
B – by the relation of species to total salt regime (Sl);

It not creates any communities in western part of Ukraine and is occurring only in one site. Sometimes it grows as accompanying species in different communities of class Potametea (Tab. 1). It is characteristic for communities with scarcity of other Potamion species. According to ecological requirements *P. friesii* is neutrophil, semi-eutroph, carbonatophil, hemi-nitrophil.

The populations of *P. obtusifolius* grows in standing or slowly running mesotrophic to oligotrophic waters of 50-100 cm depth, mainly in lakes, drainage ditches and ponds, rarely in brackish waters. It prefers peat, or clay substrata. It disappears even in temporarily polluted habitats. *P. obtusifolius* is very rare in Ukraine. In studied area it was found about 100 years ago last time. There are no communities dominated by

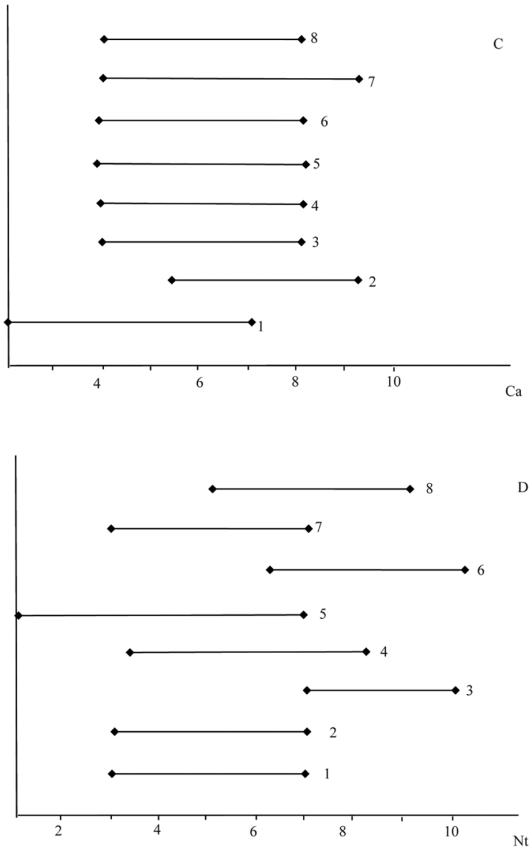

Fig. 3. cont.

C – by the relation of species to carbonat content in soil (Ca);
D – by the relation of species to nitrogen content in soil (Nt). 1-8: – rare species of the genus *Potamogeton*: 1 – P. *acutifolius* , 2 – P. *alpinus*, 3 – P. *compressus*, 4 – P. *friesii*, 5 – P. *gramineus*, 6 – P. *obtusifolius*, 7 – P. *praelongus*, 8 – P. *trichoides*

P. obtusifolius in western part of Ukraine (Tab. 1). According to ecological requirements *P. obtusifolius* is sub-acidophil, eutroph, hemi-carbonatophil, nitrophil.

The populations of *P. trichoides* form the community on sandy or peaty bottoms. *P. trichoides* is characteristic for clear mesotrophic to eutrophic waters of 50-150 cm depth or small and shallow reservoirs, often with a wide water-level range. *P. trichoides* isn't rare in Ukraine, especially in western part. Associations, in which *P. trichoides* is diagnostic species, are quite common in studied area. They usually grow in deep clear artificial water reservoirs (recreation ponds, fish-ponds). According to ecological requirements *P. trichoides* is neutrophil, semi-eutroph, carbonatophil, nitrophil.

Although these species inhabit different type of waters they are most limited by the variation of nitrogen content in soil. It can be regarded as highest discriminatory factor (Fig. 3). High nitrogen content in soil there are in artificial very polluted water reservoirs. Most of rare species need nitrogen poor water. Lowest discriminatory factor in this case is carbonat content in water, because most of the aquatic ecosystems on the studied territory have relatively high carbonat content in soil and water. Such indicators as total salt regime and pH have the mean diagnostic value. Concerning pH (soil acidity) most species need relatively neutral waters. Only one of them can grows in very alkaline aquatic reservoirs. Concerning total salt regime most species can't exist in very eutrophicated water reservoirs. Only two of them prefer eutrophic waters with large mud deposits. Thus all of the rare species have particular requirement (concerning all or one of four factors) unlike wide-spread ones.

Conclusions

Rare and threatened *Potamogeton* species were more wide-spread in the past. Limiting of their distribution nowadays are pollution, eutrophisation and anthropogene pressure on aquatic ecosystems. Therefore artificial moderately eutrophic water bodies, where these species can exist as well as places with potential opportunities for the existence of rare *Potamogeton* taxa need the protection.

The present analysis of the habitat requirements of rare *Potamogeton* species were performed from the angle of the properties of water and substrate indicates that they inhabit water reservoirs with big variation ranges of most factors. Their impact is integrated, and they exert a specific overall effect from the sum of components. Each species is influenced by some physical and chemical factors. But some components and factors have higher discriminatory value than another ones.

The phytocenoses including rare species aren't very similar. The differences between the phytocoenoses of various communities mostly involve their

structure and floristic composition as well as location in the belt distribution of vegetation. They grow on different substrates, at various depths and at sites differing in the degree of exposure to waving. Any correlation between type of aquatic reservoir and existence of species were found. But there is some phytocoenotic correlation with specific pondweed communities.

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ROZMIESZCZENIE, EKOLOGIA I FITOSOCJOLOGIA RZADKICH GATUNKÓW RODZAJU *POTAMOGETON* W CENTRALNEJ CZĘŚCI ZACHODNIEJ UKRAINY

Streszczenie

W pracy przedstawiono wyniki badań gatunków rodzaju Potamogeton, przeprowadzonych w latach 2005-2010. Wyróżniono 16 gatunków rodzaju Potamogeton występujących w centralnej części Zachodniej Ukrainy. Udział i częstość występowania tych gatunków w badanym regionie był oceniony na podstawie danych z literatury, zbiorów zielnikowych i własnych danych autora. Głównymi obiektami badań były rzadkie i zagrożone gatunki rodzaju Potamogeton. Wykazane gatunki rzadkie i zagrożone poddano analizie ekologiczno-siedliskowej i fitosocjologicznej. Ekologiczno-siedliskowe wymagania rozpatrzono w stosunku do typu zbiornika wodnego i substratu oraz 4 chemicznych parametrów (pH, typu podłoża, zawartości węglanu wapnia, zawartości związków azotowych). Wykazano w jakich zbiorowiskach wodnych występują rzadkie gatunki. Dokumentację badań zawarto w formie tabeli fitosocjologicznej.

Przeprowadzone badania potwierdziły korelację między ekologicznymi wymaganiami rzadkich gatunków i częstością ich występowania. Wszystkie gatunki wykazały odnośną zależność od ekologicznych parametrów zbiornika wodnego. Frekwencja każdego z nich zależy od zróżnicowania i kombinacji parametrów chemicznych siedliska. Największym czynnikiem ograniczającym, wpływającym na rozpowszechnienie gatunków, jest wpływ zawartości związków azotowych w wodzie, albo glebie. Najmniejszym czynnikiem ograniczającym, działającym na zagęszczenie gatunków, okazał się wpływ zawartości związków węglanu wapnia.